

CHAPTER 7 Chemical Reactions

SECTION

2

Chemical Equations

KEY IDEAS


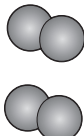

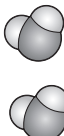
As you read this section, keep these questions in mind:

- What is a chemical equation?
- What can a chemical equation tell you?

How Can Chemical Reactions Be Described?

Suppose you watched a beautiful sunset. How would you describe it to someone else? You could write a description, take a photograph, or even draw a picture. There is more than one way to describe what you saw.

You can also describe chemical reactions in more than one way. For example, a gas stove burns methane gas to cook food. Methane gas reacts with oxygen to produce carbon dioxide and water. The figure below shows three ways you can describe this chemical reaction.

Word equation						
methane	and	oxygen	yield	carbon dioxide	and	water
Molecular model						
	+		→		+	
Chemical equation						
CH_4	+	2O_2	→	CO_2	+	$2\text{H}_2\text{O}$

Each way of describing a chemical reaction has advantages and disadvantages. For example, molecular models show how the atoms are rearranged in a chemical reaction. However, the models can be very confusing if the reactants and products are composed of many atoms.

Scientists generally use chemical equations to describe chemical reactions. A **chemical equation** uses symbols to show the relationship between the reactants and products of a reaction.

READING TOOLBOX

Review As you read this section, be sure to connect what you read with material that you learned in previous chapters. Go back if you need to review a concept or definition. Write definitions or explanations in the sidebar as reminders.

Talk About It

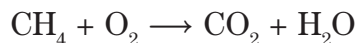
Discuss Examine the three ways of describing a chemical reaction that are shown in the figure. In a small group, discuss possible advantages and disadvantages of each type of description. Think of possible reasons scientists use chemical equations more frequently than word equations.

SECTION 2 Chemical Equations *continued***LOOKING CLOSER**

1. Explain Why does this equation disobey the law of conservation of mass?

CONSERVATION OF MASS

Recall that during a chemical change, matter cannot be created or destroyed. In other words, the total mass of the products must equal the total mass of the reactants. Look again at the chemical equation for the reaction between methane and oxygen.



The equation shows what substances are involved in the reaction. The same elements appear on both sides of the equation. Notice that there are four H atoms on the left, but only two H atoms on the right. Also notice that there are two O atoms on the left and three O atoms on the right. The chemical equation cannot be correct because it does not obey the law of conservation of mass. How can you correct the equation?

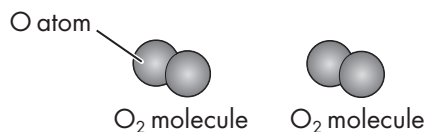
BALANCED EQUATIONS

A chemical equation can correctly describe what happens in a reaction only when it is balanced. In a *balanced* chemical equation, the number of atoms of each element is the same on both sides of the arrow. You can balance a chemical equation by placing a coefficient in front of a chemical formula. ✓

READING CHECK

2. Describe When is a chemical equation balanced?

A *coefficient* is a number that shows the relative amount of a substance in a reaction. For example, 2O_2 indicates that 2 molecules of O_2 are involved in a reaction.

**LOOKING CLOSER**

3. Identify How many total oxygen atoms are represented by " 2O_2 "?

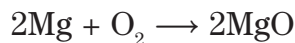
BALANCING EQUATIONS

How would you write a balanced equation for the reaction between magnesium (Mg) and oxygen (O_2) that forms magnesium oxide (MgO)?

SECTION 2 Chemical Equations *continued*

Step 1: Write a word equation for the reaction.	magnesium + oxygen \rightarrow magnesium oxide	
Step 2: Write the formula for each reactant and product.	$\text{Mg} + \text{O}_2 \rightarrow \text{MgO}$	
Step 3: Count the atoms of each element on both sides of the equation.	Reactants $\text{Mg} + \text{O}_2$ Mg: 1 O: 2	Products MgO Mg: 1 O: 1
Step 4: Add one or more coefficients to balance the number of atoms.	Place the coefficient 2 in front of MgO to balance the O atoms. $\text{Mg} + \text{O}_2 \rightarrow 2 \text{MgO}$	
	Reactants Mg: 1 O: 2	Products Mg: 2 ✗ O: 2 ✓
	Place the coefficient 2 in front of Mg to balance the Mg atoms $2\text{Mg} + \text{O}_2 \rightarrow 2 \text{MgO}$	
	Reactants Mg: 2 O: 2	Products Mg: 2 ✓ O: 2 ✓

The total number of Mg and O atoms is the same on both sides of the equation. Therefore, the equation is balanced.

**HINTS FOR BALANCING EQUATIONS**

Keep the following points in mind when you balance a chemical equation:

- Be sure that you write each formula correctly.
- You cannot change the subscripts within a chemical formula. You can only place a coefficient in front of a formula.
- The number 1 is never written as a coefficient in an equation or as a subscript in a formula.
- When you add a coefficient to balance one element, look to see if another element becomes unbalanced.
- Do a final check to see if the atoms for all elements are balanced.

Math Skills**4. Balance Equations**

Sodium sulfide, Na_2S , reacts with silver nitrate, AgNO_3 , to form sodium nitrate, NaNO_3 , and silver sulfide, Ag_2S . Write the balanced equation for this reaction.

Critical Thinking

5. Infer Why must you add coefficients to balance an equation instead of changing subscripts in a chemical formula?

SECTION 2 Chemical Equations *continued***LOOKING CLOSER**

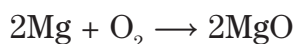
6. Explain Does this equation obey the law of conservation of mass? Explain your answer.

 **READING CHECK**

7. Identify What do the coefficients in a balanced equation tell you?

What Are Mole Ratios?

Consider again the reaction between magnesium and oxygen to produce magnesium oxide.



The balanced equation tells you that two Mg atoms react with one O₂ molecule to produce two MgO molecules. The coefficients in a balanced equation also tell you the mole ratio. The **mole ratio** is the proportion of reactants and products in a chemical reaction.

Recall that chemists use a counting unit called the mole to indicate the number of particles in a sample of a substance. One mole is the amount of a substance that contains 6.022×10^{23} particles. The coefficients in a balanced equation tell you the relative number of moles of reactant and product in the reaction. ✓

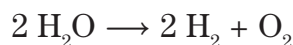
In the reaction between Mg and O₂ atoms, 2 moles of Mg are needed for every 1 mole of O₂. The reaction produces 2 moles of MgO. No matter how much magnesium and oxygen combine or how much MgO is made, the balanced equation does not change. This follows the *law of definite proportion*.

Law of Definite Proportion

A compound always contains the same elements in the same proportion. This is true regardless of how the compound forms or how much of it forms.

USING MOLE RATIOS

You can use mole ratios to predict how much of a substance is involved in a chemical reaction. For example, consider what happens when electrical energy causes water to form hydrogen and oxygen. The balanced equation for the reaction is shown below. Notice that 2 moles of H₂O produce 2 moles of H₂ and 1 mole of O₂.



SECTION 2 Chemical Equations *continued*

Electrical energy causes water molecules to break into oxygen and hydrogen.



The equation tells you the mole ratio between any two substances in this reaction. For example, the mole ratio of H_2O to O_2 is 2:1. You can use this mole ratio to predict what will happen under certain conditions.

Assume that 4 moles of O_2 are produced in this reaction. How many moles of H_2O reacted? The balanced equation gives you the mole ratio.



Therefore, twice as many moles of H_2O are needed as moles of O_2 . If 4 moles of O_2 are produced, how many moles of reactant (H_2O) did you have?

$$2x = 4 \text{ moles}$$

$$x = 8 \text{ moles of } \text{H}_2\text{O}$$

If you know the mole ratios of substances in a reaction, you can determine the relative masses of the substances. Consider again the reaction of magnesium and oxygen to produce magnesium oxide. What mass of Mg would you need to react with 2 moles of oxygen?

Step 1: Write the balanced equation and identify the coefficients for the substances.	$2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$ Mg: 2 O ₂ : 1 MgO: 2
Step 2: Calculate the molar masses of the substances.	Mg: 24.3 g/mol O ₂ : 32.0 g/mol MgO: 40.3 g/mol
Step 3: Multiply the mole ratio for each substance by its molar mass.	Mg: 2 mol \times 24.3 g/mol = 48.6 g O ₂ : 1 mol \times 32.0 g/mol = 32.0 g MgO: 2 mol \times 40.3 g/mol = 80.6 g

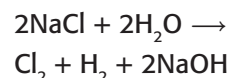
You would need to use 48.6 g of Mg to react completely with 2 moles of O.

Critical Thinking

8. Apply Concepts How many moles of Mg would you need to react with 2.5 moles of O_2 ?

Math Skills

9. Calculate Chlorine gas can be produced in the following reaction:



What mass of NaCl do you need to make 71 g of Cl_2 ? (Hint: Use the periodic table in the back of the book to help you calculate the molar masses.)

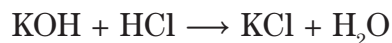
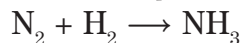
Section 2 Review

SECTION VOCABULARY

chemical equation a representation of a chemical reaction that uses symbols to show the relationship between the reactants and products

mole ratio the relative number of moles of the substances required to produce a given amount of product in a chemical reaction

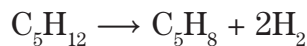
1. Balance Equations Write balanced equations for the reactions below.



2. Explain Why must you balance an equation to describe correctly what happens in a chemical reaction?

3. Interpret What does $4\text{H}_2\text{O}$ tell you about the number of molecules and the total number of atoms of each element?

4. Calculate What is the mole ratio of C_5H_{12} to H_2 in the following reaction?



5. Identify Relationships Does adding coefficients to a chemical equation disobey the law of definite proportions? Explain your answer.
